Acta Scientific Ophthalmology (ISSN: 2582-3191)

Volume 8 Issue 5 May 2025

Research Article

Comparison of Subjective and Objective Techniques to Evaluate Amplitude of Accommodation Among Indian Undergraduate Students

Ankur Banik*, Priya Darshini and Samritha Gangatharan

Department of Optometry, Sapthagiri Institute of Medical Sciences and Research Center, Bangalore, India

***Corresponding Author:** Ankur Banik, Department of Optometry, Sapthagiri Institute of Medical Sciences and Research Center, Bangalore, India.

Received: April 23, 2025

Published: April 29, 2025

Abstract

Purpose: The study aimed to compare the amplitude of accommodation measured using subjective and objective techniques among students at a private Indian institute. Additionally, the study sought to determine correlation between these techniques.

Design: A cross-sectional observational study was conducted

Methods

- Settings: The study was conducted at our institute outpatient department of optometry.
- Study population: 60 undergraduate optometry students aged 19 and 28 years participated. Inclusion criteria included spherical myopia (-0.50 D to -10.00 D), spherical hypermetropia (+0.75 D to +5.00 D), and emmetropia, with astigmatism ≤ 0.75 D.
- Intervention/Observation Procedures: Amplitude of accommodation was measured using three subjective (push-up, pull-away, and minus lens) and two objective (dynamic retinoscopy and Pascal heterodynamic retinoscopy) techniques.
- Main Outcome Measures: Mean amplitude of accommodation values across different techniques and refractive groups, along with correlations between subjective and objective techniques.

Results: Subjective methods yielded higher amplitude of accommodation values than objective techniques across all refractive groups ($p < 0.001$). The push-up technique reported the highest values, followed by pull-away, minus lens, dynamic retinoscopy, and pascal heterodynamic retinoscopy. Myopes exhibited the highest amplitude of accommodation values, followed by emmetropes and hypermetropes. A strong positive correlation was observed between dynamic retinoscopy and Pascal heterodynamic retinoscopy ($r = 0.996$, $p < 0.001$).

Conclusions: Subjective amplitude of accommodation measurement techniques tends to overestimate values compared to objective techniques. A very strong positive correlation was observed between dynamic retinoscopy and pascal heterodynamic retinoscopy.

Keywords: Amplitude of Accommodation; Subjective Technique; Objective Technique; Myopia; Hypermetropia; Emmetropia

Abbreviations

AA: Amplitude of Accommodation; DR: Dynamic Retinoscopy; PHDR: Pascal Heterodynamic Retinoscopy; PU: Push-Up; PA: Pull-Away; ML: Minus Lens; D: Diopters; SD: Standard Deviation

Introduction

Ocular accommodation refers to the eye's capacity to alter its focus to observe objects clearly at varying distance [1,2]. This system is essential in maintaining clear vision as the eye focuses between near and far objects. The term amplitude of accommodation (AA) describes how the dioptric power of the eye changes to focus on closer objects [3]. Understanding the process of accommodation and the methods for measuring its amplitude provides insights into the visual function and age-related changes of the eye.

AA can be assessed clinically with subjective (Push-up, pull-away, and minus lens) or objective (Dynamic retinoscopy and pascal heterodynamic retinoscopy) methods [1,4,5]. Subjective measurements can be affected by dept of focus and individual variation and may overestimate or underestimate AA. Conversely, objective measurements are independent of patient response, giving a more accurate assessment of accommodative function [4]. Studies showed significant differences between these methods, with objective technique yielding lower AA values than subjective technique [1,4,6].

Refractive errors like myopia, hypermetropia, and emmetropia can affect AA. Previous study established that myopes between 35 and 44 years had greater AA than their emmetropic and hypermetropic counterparts [7]. Study conducted by McBrien and Millodot [8] using the push-up and pull-away methods among university students aged between 18 and 22 years showed AA of 10.77, 9.87, 9.28, and 8.63 diopters for early-onset myopes, late-onset myopes, emmetropes, and hyperopes, respectively.

This study aimed to provide a clinical baseline for AA measured using subjective (Push-up, pull-away, and minus lens) and objective (dynamic retinoscopy and pascal heterodynamic retinoscopy) techniques with different refractive statuses: emmetropes, myopes, and hypermetropes in students at a private Indian institute. This study also aimed to correlate between the techniques for measuring the AA.

Methods

Recruitment and enrollment

Participants were recruited from our institute outpatient department of optometry. The study was reviewed and approved by the Institutional Ethical and Scientific Committee and followed the tenets of the Declaration of Helsinki. Informed consent was obtained from each participant after the nature, possible consequences, and procedures of the study were explained to them.

Eligible participants were under-graduate optometry students aged between 19 and 28 years and had between -0.50 D to -10.00 D of spherical myopia, +0.75 D to +5.00 D of spherical hypermetropia with ≤ 0.75 D of astigmatism and emmetropia. Participants were also required to be wearing single-vision spectacle lenses, with prescription of at least 2 – 3 months old. Participants had a best-corrected acuity of at least 0.00 logMAR (6/6) at 4 m and N6 at 30 cm in each eye. The exclusion criteria were any systemic or ocular conditions, medications that may interfere with accommodation, no ocular surgery including extraocular muscles, oculomotor dysfunction, neurological disorders, not strabismic and not amblyopic.

Baseline examination

Total 60 participants were enrolled in this cross-sectional study and all participants attended one institutional department OPD visit wearing their habitual spectacle lenses. All participants were verbally questioned regarding their medical history including general and ocular health, family ocular history, date of last eye examination, allergies, medication, occupation, driving, visual display unit use, and hobbies. This was followed by measuring the logMAR monocular visual acuity with habitual lenses recorded at 4 m (I Chart HD Smart, Appasamy Associates, India) and 30 cm (MNREAD Acuity Chart Card; Precision Vision, Woodstock, IL), stereopsis (Titmus fly test), extraocular muscle motility, cover test, and pupillary evaluation. Balanced subjective refraction for each eye was performed to ensure accommodative effort exerted by each eye was equally balanced. An Appasamy slit-lamp biomicroscope, AIA-11 (Appasamy Associates, India), was used to assess the anterior ocular surface.

To standardize the tests, all participants followed the same sequence of dynamic retinoscopy, pascal heterodynamic retinoscopy, push-up technique, pull-away technique, and minus lens technique. A 10-minutes break was given after conducting each technique to avoid fatigue. All the tests were conducted by a single examiner, and the results were recorded under the supervision of another observer to avoid bias.

Dynamic retinoscopy was performed monocularly in a dimly lit room using a retinoscope while the participants had their habitual distance correction. A target at 40 cm was positioned and the participants were instructed to read and maintain clear vision of the letters. The examiner sitting at 40 cm away noted the horizontal movement of the retinoscopic reflex (with or against movement) to determine whether to move inwards or outwards to achieve neutrality. The measurements were then taken at the spectacle plane when neutrality was attained at the correct distance from the retinoscope. The AA was determined as the reciprocal of the distance in meters [1,4]. Three measurements were performed, and the average value was recorded.

Pascal heterodynamic retinoscopy was performed monocularly with the left eye occluded in a dimly lit room using a retinoscope while the participants had their distance correction in the trail frame. The fixation target was positioned close to the trail frame at a point where the letters were blurry. The participants were then asked to gradually push the handheld reduced Snellen chart until the letters were just readable, while maintaining sharp and clear vision of the letters. Once the target had reached this subjective point, the examiner set the retinoscope at a working distance about twice that between the fixation chart and participant. The retinoscopic reflex was noted, and if an "against" movement was noted, the examiner moved closer to the eye until neutrality was achieved. Once neutrality was achieved, the distance between the spectacle plane and the retinoscope was measured using a measuring tape. The AA was calculated as the reciprocal of this distance in meters. Three measurements were performed, and the average value was recorded.

The push-up technique was carried out using the Royal Air Force (RAF) rule, which specifies that the target should be moved at a steady speed of 5 cm/sec. The test was carried out monocularly with the target initially placed at 40 cm. Participants were instructed to fixate on an N5 target. The target was gradually brought closer at a constant pace until they reported a blur. The AA was calculated as the reciprocal of the distance between the target and the eye at the point of first sustained blur. Each eye underwent three measurements and the average result was recorded as AA.

The pull-away test was performed monocularly in the similar manner as the push-up test using the RAF rule. In this method, the target was moved from a near position to a distance until the participants reported clear target. The participants were instructed to adjust the N5 target to achieve clarity at a uniform speed of 5 cm/sec. The AA was calculated as the reciprocal of the distance from the target-to-eye distance at the point of clarity. Each eye underwent three measurements and the average result was recorded as AA.

The minus lens procedure was performed with a trail frame to ensure a fixed vertex distance during the test. This test was done monocularly; where the participants were instructed to see an N5 target at 33 cm to offset the minification produced by the minus lens when placed at 40 cm [9]. Minus spherical lenses were added successively to the distance correction in 0.25 D increments until the participants experienced blurring. The number of spherical minus lenses added to the distance refraction was calculated and the AA was the minus lens power added to the distance refraction plus 2.5 D, accounting for potential overestimation due to target's proximity [10].

Statistical analysis

The data were entered into a Microsoft Excel spreadsheet and analyzed using SPSS version 20.0 (IBM, Somers, NY, USA) statistical software and significance was set at 5%. Measures of central tendencies including means, standard deviations, and range were calculated. Shapiro-Wilk test was conducted to check the normality of the data. To compare the mean measurements from the push-up, pull-away, minus lens, dynamic retinoscopy, and pascal heterodynamic retinoscopy among emmetropes, myopes and hypermetropes a one-way analysis of variance (ANOVA) was conducted. Pearson correlation was used to find out the relationship between each objective and subjective techniques. The strength of correlation was analyzed using Evans guidelines. A paired sample *t*-test was carried out to assess significant differences between the right eye and left eye for each technique. No such significant difference was found, and the measurements of the right eye were considered for statistical analysis.

Results

Demographic data

Sixty under-graduate optometry students were enrolled in this study. The AA was assessed using both subjective (Push-up, pull-away, minus lens) and objective (Dynamic retinoscopy and pascal heterodynamic retinoscopy) techniques among emmetropes, myopes, and hypermetropes. This study included 29 (46.67%) male and 31 (53.33%) female participants. The average age of all participants was 23.98 ± 3.23 years ranging from 20 to 27 years of age. The mean subjective refraction for emmetropes, myopes, and hypermetropes were 0.00 D, -1.25 D, and +1.75 D respectively.

Comparison of the procedures for measuring AA among emmetropes, myopes, and hypermetropes

Table 1 shows the comparison of all the procedures used in this study to measure AA among emmetropes, myopes, and hypermetropes. The mean, SD, minimum and maximum values obtained using each tests are listed.

The mean AA for the push-up in emmetropes, myopes and hypermetropes was 10.77 ± 0.97D, 12.60 ± 2.15D and 8.77 ± 1.44D respectively ($p < 0.001$). The mean AA for pull-away in emmetropes, myopes and hypermetropes was 10.02 ± 1.00D, 11.10 ± 1.61D and 8.41 ± 1.33D respectively ($p < 0.001$). Mean AA for minus lens method for emmetropes, myopes and hypermetropes was 7.86 ± 0.40D, 8.17 ± 0.58D and 6.80 ± 0.58D respectively ($p < 0.001$). In dynamic retinoscopy, the mean AA for emmetropes, myopes and hypermetropes was 6.06 ± 0.25D, 6.24 ± 0.26D and 5.81 ± 0.23D respectively ($p < 0.001$). Pascal heterodynamic retinoscopy showed a mean value of 6.03 ± 0.25D, 6.22 ± 0.26D and 5.78 ± 0.23D for emmetropes, myopes and hypermetropes respectively ($p < 0.001$).

	Push-up (D)	Pull-away (D)	Minus lens (D)	Dynamic retinoscopy (D)	Pascal heterodynamic retinoscopy (D)
Emmetropes					
Mean ± SD	10.77 ± 0.97	10.02 ± 1.00	7.86 ± 0.40	6.06 ± 0.25	6.03 ± 0.25
Minimum	9.09	8.58	7.16	5.70	5.69
Maximum	12.03	11.88	10.58	10.05	9.89
Myopes					
Mean ± SD	12.60 ± 2.15	11.10 ± 1.61	8.17 ± 0.58	6.24 ± 0.26	6.22 ± 0.26
Minimum	9.39	9.09	8.08	5.98	5.83
Maximum	16.66	15.07	12.00	10.11	10.00
Hypermetropes					
Mean ± SD	8.77 ± 1.44	8.41 ± 1.33	6.80 ± 0.58	5.81 ± 0.23	5.78 ± 0.23
Minimum	7.69	7.32	6.25	5.40	5.55
Maximum	11.55	10.57	9.16	9.25	8.79
p value	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$

Table 1: Comparison of all the procedures used in this study to measure AA among emmetropes, myopes, and hypermetropes.

D = diopters, SD = standard deviation.

Correlation among objective and subjective techniques for measuring AA

Table 2 shows the correlation between objective and subjective techniques for measuring AA.

A very strong positive correlation was observed between dynamic retinoscopy and pascal heterodynamic retinoscopy ($r = 0.996$, $p < 0.001$) in objective techniques, between push-up and

r	DR	PHDR	PU	PA	ML
DR	-	0.996	0.648	0.671(p = 0.009)	0.607
PHDR	0.996	-	0.655	0.675(p = 0.009)	0.603
PU	0.648	0.655	-	0.907	0.814
PA	0.671 (p = 0.009)	0.675 (p = 0.009)	0.907	-	0.794
ML	0.607	0.603	0.814	0.794	-

Table 2: Correlation (r) between objective and subjective techniques for measuring AA.

DR = dynamic retinoscopy, PHDR = pascal heterodynamic retinoscopy, PU = push-up, PA = pull-away, ML = minus lens. Strong positive correlation values are shown as bold and italics. $p < 0.001$ was considered significant and the p- value represented in brackets was not significant.

pull-away techniques (r = 0.907, p < 0.001) and minus lens and push-up techniques (r = 0.814, p < 0.001) in subjective techniques. The pull-away (r = 0.671 and 0.675, p = 0.009) and minus lens technique (r = 0.607 and 0.603, p < 0.001) showed a weak positive correlation with both dynamic and pascal heterodynamic retinoscopy respectively.

Discussion

The current study found that subjective techniques, such as the push-up (10.77 ± 0.97D, 12.60 ± 2.15D and 8.77 ± 1.44D , p < 0.001), pull-away (10.02 ± 1.00D, 11.10 ± 1.61D and 8.41 ± 1.33D , p < 0.001) , and minus lens (7.86 ± 0.40D, 8.17 ± 0.58D and 6.80 ± 0.58D , p < 0.001) methods yield higher mean AA values compared to objective techniques like dynamic retinoscopy (6.06 ± 0.25D, 6.24 ± 0.26D and 5.81 ± 0.23D, p < 0.001), and pascal heterodynamic retinoscopy (6.03 ± 0.25D, 6.22 ± 0.26D and 5.78 ± 0.23D, p < 0.001) across different refractive statuses: emmetropes, myopes, and hypermetropes respectively. This significant differences is often attributed to factors inherent in subjective assessments, including depth of focus, target size, illumination, endpoint cues, pupil size, and subject variability, which can overestimates the true AA [11].

The highest mean AA was obtained for the push-up technique followed by pull-away, minus lens, dynamic retinoscopy, and pascal heterodynamic retinoscopy. This findings are comparable with Mathebula., *et al*. [4] which indicated that the AA obtained using push-up method (10.22 ± 1.67D) was higher, followed by pull-away (9.08 ± 1.44D), minus lens (8.43 ± 1.68D), modified dynamic retinoscopy (6.58 ± 1.34D), and pascal heterodynamic retinoscopy (6.77 ± 1.42D).

There were significant variations in AA values among the three refractive groups. Myopes exhibited greater AA across all measurement techniques compared to emmetropes and hypermetropes. This result is in agreement with earlier studies that myopes have a greater accommodative response due to habitual near work and a greater accommodative effort [8]. Conversely, hypermetropes had the lowest AA values, presumably due to added accommodative demand to maintain clear near vision [7]. These findings highlight the effect of baseline refractive status on accommodative measurements.

This study showed a strong positive correlation between dynamic retinoscopy and pascal heterodynamic retinoscopy (r = 0.996, p < 0.001) in objective techniques, between push-up and pull-away techniques (r = 0.907, p < 0.001), and minus lens and push-up techniques (r = 0.814, p < 0.001) in subjective techniques. These findings are comparable with Mathebula., *et al*. [4] which showed significant correlation between modified dynamic retinoscopy and pascal heterodynamic retinoscopy (r = 0.83, p = 0.00), push-up and push-down (r = 0.85, p < 0.00), and minus lens and push-up (r = 0.81, p = 0.00) techniques. These techniques can be used interchangeably in clinical settings.

Conclusion

This study highlights the important differences between the subjective and objective techniques for measuring AA across different refractive statuses: emmetropes, myopes, and hypermetropes. Subjective techniques such as the push-up and pull-away methods overestimating the true AA. The values obtained using objective techniques showed reduced AA than that using the subjective techniques. Moreover, strong correlation was obtained between dynamic retinoscopy and pascal heterodynamic retinoscopy in objective techniques, between push-up and pull-away techniques and minus lens and push-up techniques in subjective techniques. These suggest that these techniques can be used interchangeably in clinical settings.

Acknowledgements

We would like to thank everyone who participated in this study. Special gratitude goes to the management of the Sapthagiri Institute of Medical Sciences and Research Center, Bangalore, without their support this study could not be conducted. Furthermore, we would like to thank Ms. Ashwini for her technical help in analyzing the data.

Funding Information

This research received no funding from any source.

Conflict of Interest Statement

There are no conflicts of interests.

Bibliography

1. Majumder C and Afnan H. "Amplitude of Accommodation among Students of a Malaysian Private University as Assessed Using Subjective and Objective Techniques". *Korean Journal of Ophthalmology* 34.3 (2020): 219-226.

2. Adler FH and Kaufman PL. editors. "Adler's physiology of the eye: clinical application". St. Louis: Mosby; (2003): 41.

3. Elliott DB. "Clinical procedures in primary eye care (5th Ed.)". Elsevier/Butterworth Heinemann (2021).

4. Mathebula SD., *et al*. "Comparison of the amplitude of accommodation determined subjectively and objectively in South African university students". *African Vision and Eye Health* 77.1 (2018): 1-10.

5. Anderson HA and Stuebing KK. "Subjective versus objective accommodative amplitude: preschool to presbyopia". *Optometry and Vision Science* 91.11 (2014): 1290-1301.

6. Momeni-Moghaddam H., *et al*. "Comparing measurement techniques of accommodative amplitudes. *Indian Journal of Ophthalmology* 62.6 (2014): 683-687.

7. Abraham LM., *et al*. "Amplitude of accommodation and its relation to refractive errors". *Indian Journal of Ophthalmology* 53.2 (2005): 105-108.

8. McBrien NA and Millodot M. "Amplitude of accommodation and refractive error". *Investigative Ophthalmology and Visual Science* 27.7 (1986): 1187-1190.

9. Majumder C and Zaimi NZ. "Comparison of amplitude of accommodation in different room illumination while using VDU as a target". *International Journal of Ophthalmic Research* 3.3 (2017): 243-248.

10. Scheiman M and Wick B. "Clinical management of binocular vision: heterophoric, accommodative, and eye movement disorders". 4th ed. Philadelphia: Lippincott Williams and Wilkins. (2015): 20.

11. Alilionwu A., *et al*. "The Comparison of Subjective and Objective Clinical Methods of Assessing Amplitude of Accommodation". *Acta Scientific Ophthalmology* 7.3 (2024): 10-26.